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Internal Correspondence

MARTIN MARIETTA ENERGY SYSTEMS, INC.

June 10, 1991

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Historical Radionuclide Release Report (OR-890) Update

As you know, the Environmental Protection Division (ENV-PD) personnel at the Department of Energy are in the process of updating the Historical Radionuclide Release Report (OR-890) through CY 1990. F. R. O'Donnell, Oak Ridge National Laboratory, has updated the radiological dose and health effects section using the annual release information which you submitted. Attached is a copy of the updated information.

Please review the information quickly. If you or your staff have comments, we need to know by close of business tomorrow, June 11, 1991. I apologize for the quick turnaround; however, ENV-PD personnel want to proceed with publication of the document, and Frank O'Donnell will be unavailable for two weeks beginning June 12, 1991 noon.

JGRogers

J. G. Rogers, K-1001, MS 7155, (4-898~

JGR:jr

Attachment

cc: C. C. Hill
F. C. Kornegay
F. R. O'Donnell
C. L. Stair
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Document: # Unnumbered, 1-page ltr, JG Rogers to RE Blake ~~et al, dtd 6/10/91,~~ Date ~~HISTORICAL RADIO-~~
Title/Subject ~~NUCLIDE RELEASE REPORT (OR-890) UPDATE~~
and 7-page attachment

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4.0 RADIATION DOSES TO THE PUBLIC FROM RELEASES

4.1 Introduction

This section attempts to put into perspective the potential consequences of the radionuclide releases described in the previous sections. These consequences are expressed in terms of the radiation doses that could have been received by members of the public and the risks associated with reception of the radiation doses. Because many uncertainties and gaps exist in our knowledge of actual radionuclide releases and of the meteorological and hydrological conditions that existed over the many years of plant operation, the dose estimates presented below are, at best, order-of-magnitude estimates. A more detailed evaluation of radionuclide releases and associated radiation doses is planned.

Most consequences to humans from radionuclides released to the environment are caused by interactions between radiations (e.g., alpha particle, beta particles, and gamma rays) emitted by the nuclides and human tissue. These interactions involve the transfer of energy from the radiations to the tissue, a process that may damage the tissue. The radiations may come from radionuclides located outside the body (i.e., in or on environmental media and man-made objects) and from radionuclides deposited inside the body via inhalation, ingestion, and absorption through the skin. Exposures to radiations from nuclides located outside the body are called external exposures and will last only as long as the exposed person is near the external sources. Exposures to radiations from radionuclides deposited inside the body are called internal exposures and will last as long as the radionuclides remain in the body.

A number of specialized units are used to characterize exposures to ionizing radiations. Because the damage associated with such exposures is due primarily to the deposition of radiant energy in tissue, these units are described in terms of the amount of radiant energy absorbed by the tissue and the biological consequences of the absorbed energy. Some of these units are defined below.

The absorbed dose is the amount of radiant energy absorbed per unit mass of any irradiated material. Its unit of measure is the rad.

A dose equivalent is a measure of the biological effectiveness of an absorbed dose in a specified human organ or tissue. Its unit of measure is the rem and is equal numerically to the absorbed dose multiplied by modifying factors that relate absorbed dose to biological effects.

An effective dose equivalent (EDE) is the sum of dose equivalents to a specified set of organs and tissues. Its unit of measure also is the rem. An EDE is based on the overall carcinogenic and genetic risk to humans from reception of radiation dose equivalents. The EDE is the measure of radiation dose used in this report.

A committed (effective) dose equivalent is the total (effective) dose equivalent that will be received over a specified period of time (usually 50 years) because of exposures to and intakes of radionuclides released during the year of interest.

A collective (committed) EDE is the sum of (committed) EDEs to each individual in the exposed population. Its unit of measure is the person-rem.

4.2 Estimation of Radiation Doses

Members of the public may receive radiation doses via various exposure pathways because of the previously described radionuclide releases. For radionuclides discharged to the atmosphere, a person may inhale and be immersed in airborne radionuclides, may be exposed to radionuclides deposited on the ground, and may eat foods (e.g., milk, meat, vegetables, and produce) that contain radionuclides that have deposited on or been taken up by the foods. For radionuclides discharged to water, a person may drink the water and eat fish that contain radionuclides taken up from the water. The other potential water exposure pathways (e.g., swimming, boating, and fishing) add insignificantly to the doses from drinking water and eating fish.

Usually, radionuclide releases from a plant and associated radiation doses are too small to be measured in the environment. Therefore, computer models are used to simulate transport of the radionuclides from the point of release and to calculate potential radiation doses to man. These calculations are made using computer codes recommended by appropriate regulatory agencies (e.g., the U. S. Environmental Protection Agency). Site-specific data (source characteristics, release quantities, meteorological and climatological conditions, locations of people, and food production information) are input to the codes. These calculations are now performed annually to determine the 50-year committed EDE to the most exposed person near each plant and to the entire population within 80 km (50 mi) of the plant. However, for much of the time that the facilities considered in this report have been in operation, the needed computer codes and formal programs for collecting needed data did not exist. Therefore, the estimated collective EDEs to the public over the lifetime of each plant given in this report should be considered order-of-magnitude estimates; they are based on incomplete information and on the assumption that current release and exposure conditions are similar to those that existed throughout the facility lifetimes.

Table 4.2.1 contains (1) the estimated number of persons residing within 80 km (50 mi) of each facility during 1990 and the average number of such persons over the lifetime of the facility, (2) the calculated EDE to the maximally exposed individual from atmospheric emissions from each facility during 1989, and (3) the calculated collective 50-year committed EDE to the public due to releases of radionuclides from each facility to the atmosphere and to water over the facility lifetime. For perspective, Table 4.2.1 also contains an estimate of the collective EDE that each plant population would have received from natural sources of radiation (see Table 4.2.2) over the lifetime of the facility. The average resident of the United States receives an EDE of approximately 300 mrem each year from natural sources. The maximally exposed individual for any plant considered is expected to receive no more than about one millirem from atmospheric releases under current conditions. The collective EDEs from plant emissions (both to air and water) are very much smaller than the expected collective EDEs to the plant populations from natural sources.

The collective EDE to a population surrounding a plant (viz., the K-25 Site, ORNL, the Y-12 Plant, the Paducah Gaseous Diffusion Plant, and the Portsmouth Gaseous Diffusion Plant) due to atmospheric emissions over the life of the plant was obtained as follows.

(1) Calculate a collective dose factor (rem/Ci) for each radionuclide: divide the collective EDE (person-rem) calculated for the 1989 annual surveillance report by the activity (Ci) of the nuclide emitted and the number of persons exposed.

(2) Calculate a cumulative (through 1985) collective EDE for each nuclide: multiply the collective dose factors (rem/Ci), the total activity (Ci) released from plant start-up through 1985 (Table 1, Appendix A), and the average number of persons exposed each year (see Table 4.2.1).

(3) Calculate a cumulative (through 1985) collective EDE for all nuclides: sum the nuclide-specific collective EDEs calculated in Step 2.

(4) Calculate the cumulative (through 1990) collective EDE: add to the values calculated in Step 3 the collective EDEs reported in the annual surveillance reports for 1986 through 1990.

The collective EDE given in Table 4.2.1 for ORNL includes doses due to estimated releases of about 2000 Ci of ^{131}I and 6.8×10^6 Ci of noble gases that might have been released to the atmosphere from some early processes. These potential releases are not included in Table 1, Appendix A.

Potential collective 50-year committed EDEs to the public due to liquid releases of radionuclides from the ORR facilities were obtained as follows.

(1) Calculate an effective concentration of each radionuclide in off-site water: divide the total activity of each radionuclide released to water through 1990 by a typical Tennessee River flow, 2.4×10^{13} L/year.

(2) Assume that each person in the exposed population, the approximately 303,000 persons who drink river water between Oak Ridge and Chattanooga, drinks 310 L of undiluted, unfiltered river water per year.

(3) Calculate the total intake of each radionuclide via drinking water: multiply the effective concentration in off-site water, 310 L/year, and the exposed population.

(4) Calculate the effective concentration of each radionuclide in fish: multiply the effective radionuclide concentration in off-site water by the appropriate fish to water bioaccumulation factor.

(5) Assume that 10% of the exposed population (30,300 persons) eats 7.3 kg/year of sport fish and an additional 6850 persons eat 7.3 kg/year of commercially caught and processed fish.

(6) Calculate the total intake of each radionuclide via eating fish: multiply the effective concentration in fish, 7.3 kg/year, and 37,150 persons who are assumed to eat fish.

(7) Calculate the total activity of each nuclide ingested by the exposed population: sum Steps 3 and 5.

(8) Calculate collective 50-year committed EDE due to ingestion of each radionuclide: multiply the total intake (Step 6) and the ingestion dose conversion factor for the nuclide.

(9) Calculate the collective 50-year committed EDE to the population from ingestion of all waterborne radionuclides: sum the results of Step 7 for each radionuclide released to water.

A similar methodology was used to estimate doses from waterborne releases from the Portsmouth Plant. In this case the total nuclide inventory was diluted into a typical Scioto River flow (4.6×10^{12} L/year). The Scioto River is not classified as a drinking water source by the Ohio EPA and, to the best of DOE's knowledge and belief, nobody actually drinks water from the river. Also, there is no commercial fishing and only limited sport fishing in the river. Therefore, the most realistic estimate of collective EDE is zero (essentially no one is exposed). However, since it cannot be proven that no one drinks water and eats fish from the Scioto River, a collective EDE for the Portsmouth Plant is given in Table 4.2.1 for a population of one person who drinks 310 L/year of water and eats 7.3 kg/year of fish from the Scioto River.

4.3 Uncertainties In Dose Calculations

As noted above, many factors contribute to uncertainty in the dose calculations. Thus the reported doses should be regarded as order-of-magnitude estimates that will be refined when a more detailed study of releases and exposure conditions is completed. Some of the major contributors to uncertainty are:

(1) Incomplete radionuclide release data, as discussed above. This is a major source of imprecision in the dose estimates.

(2) It was assumed that 1989 environmental conditions could be used to represent conditions that existed during the entire release periods. Therefore, one set of agricultural production and food consumption data, one set of meteorological and climatological conditions, and an average number of exposed persons were assumed representative of all years. Undoubtedly, these conditions changed almost yearly and could have changed dramatically over the time span considered.

(3) Environmental transport of radionuclides, their uptake by man, and the radiation doses resulting from those uptakes are calculated using mathematical models. At best, such models are only approximations of reality. Usually, the models are designed to lead to overestimates of true radionuclide uptakes and radiation doses. There is no guarantee that overestimation always occurs. However, experience with the models used for these estimates indicates overprediction of radiation doses by about a factor of two.

4.4 Significance of Calculated Radiation Doses

The significance of a radiation dose can be put into perspective by comparing it to doses from natural sources or by estimating the health risk associated with the dose. Comparison of radiation doses from plant emissions with those from natural sources indicates that plant-derived doses are but a very small fraction (less than 1%) of doses from natural sources (see Sect. 4.2 and Table 4.2.1).

Estimation of health risks due to reception of radiation doses is a controversial area of health physics. The controversy centers not on whether there is a risk, but on how to estimate the risk (which model correctly relates dose to risk). Some argue that there is a risk associated with any dose; others argue that there is no, or very little, risk associated with reception of radiation doses at a low rates, such as those given in this report. To put the potential health risks into perspective, we use the risk factor most recently recommended by the International Commission on Radiological Protection, the risk of development of a fatal cancer or genetic defect is about 0.0006 per person-rem of EDE.

Table 4.4.1 contains estimates of the health risks associated with radionuclide releases from the facilities considered. The risks were estimated by multiplying the collective EDEs given in Table 4.2.1 and the chosen risk factor. The numbers can be interpreted to be the numbers of fatal cancers and genetic defects that might develop in the entire population that resided within 50 miles of the named facility during the entire period of facility operation. For comparison, Table 4.4.1 also exhibits the estimated risk to the affected populations due to exposures to natural background radiations. The same line of reasoning was used to calculate effects due to natural background and to radionuclide emissions.

Table 4.2.1. Recent maximum individual EDEs and collective 50-year committed EDEs from plant operations and from natural background.

Plant	K-25	Y-12	ORNL	Paducah	Portsmouth	FMPC	RMI
Reporting period	1946-90 44 years	1944-90 46 years	1949-90 41 years	1952-90 38 years	1955-90 35 years	1951-90 39 years	1962-90 28 years
Number of persons residing within 50 miles:							
average	752,000	750,000	730,000	405,000	546,000	?	?
current	907,757	949,300	933,362	535,211	607,000	2,643,277	1,645,430
Calculated EDE (mrem) to maximally exposed individual during 1989							
	0.004	1	0.3	0.0001	0.07	1	0.00004
Calculated collective EDE (person-rem) over the entire reporting period:							
Liquid releases	20	100	2000	(a)	<1		
Airborne releases	400	4000	1000	200	30		
Total	400	4000	3000	200	30		
Natural background	10,571,000	10,343,000	9,196,000	4,710,000	5,823,000		

(a) The collective EDE due to liquid effluents is believed trivial because few if any persons drink water and eat fish from streams that receive liquid effluents.

Table 4.2.2.

Table 4.1.3 from OR-890 should be used as Table 4.2.2.

Table 4.4.1. Estimated Health Effects from Historical Releases from DOE-OR Facilities Through 1990

Facility	Operating time (years)	Number of health effects from facility releases	natural background
K-25	44	0.2	6300
Y-12	46	2	6200
ORNL	41	2	5500
Paducah GDP	38	0.1	2800
Portsmouth GDP	35	0.02	3500
FMPC	?	?	?
RMI	?	?	?

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